CLAIMS

What we claim is:

5   1.   A method of controlling a horizontal directional drilling (HDD) machine having a cutting tool coupled to a drill pipe, comprising:

controlling the HDD machine to move the cutting tool along an underground path in accordance with a pre-established bore plan;

detecting, from above-ground, cutting tool movement;

10   accessing, during HDD machine operation, one or more control programs, each of the control programs causing the HDD machine to execute a sequence of pre-defined HDD machine actions; and

executing a particular control program of the one or more control programs to augment movement of the drill pipe or cutting tool.

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2.   The method of claim 1, wherein detecting cutting tool movement comprises confirming that the cutting tool is progressing along the underground path.

3.   The method of claim 1, wherein the particular control program defines a
20   sequence of cutting tool location detection actions, and detecting cutting tool movement comprises detecting cutting tool orientation during execution of the sequence of cutting tool location detection actions.

4.   The method of claim 1, wherein the particular control program defines a
25   sequence of cutting tool location detection actions, and detecting cutting tool movement comprises detecting cutting tool depth during execution of the sequence of cutting tool location detection actions.

5.   The method of claim 1, wherein the particular control program defines a
30   sequence of cutting tool location detection actions, and detecting cutting tool movement

comprises detecting cutting tool location during execution of the sequence of cutting tool location detection actions.

6.   The method of claim 1, wherein detecting cutting tool movement comprises detecting a deviation of the cutting tool from the underground path, and execution of the particular control program augments movement of the cutting tool to change a heading of the cutting tool.

7.   The method of claim 6, wherein the heading of the cutting tool is changed to direct the cutting back to the underground path.

8.   The method of claim 6, wherein the heading of the cutting tool is purposefully changed to direct the cutting tool away from the underground path.

9.   The method of claim 1, wherein detecting cutting tool movement comprises detecting an underground obstruction, and execution of the particular control program augments movement of the cutting tool to avoid the detected underground obstruction.

10.   The method of claim 1, wherein accessing the one or more control programs further comprises manually selecting the particular control program for execution.

11.   The method of claim 1, wherein accessing the one or more control programs further comprises automatically selecting the particular control program for execution.

12.   The method of claim 1, wherein the cutting tool comprises a boring tool or a reamer, and the one or more control programs define a sequence of boring tool or reamer actions to enhance progression of the boring tool or reamer through earth.

13.   The method of claim 1, wherein the one or more control programs define a sequence of rod loading or unloading actions.

14.   The method of claim 1, wherein the HDD machine comprises a mud system, further wherein the one or more control programs define a sequence of mud system actions.

15.   The method of claim 1, wherein the one or more control programs comprise instructions that replicate an operator defined sequence of HDD machine actions.

16.   The method of claim 1, further comprising:

manually performing the sequence of pre-defined HDD machine actions; and

storing program instructions during manual performance of the sequence of pre-defined HDD machine actions, the one or more control programs comprising the stored program instructions.

17.   The method of claim 1, further comprising detecting a change in an HDD machine performance characteristic, wherein executing the particular control program modifies movement of the drill pipe or cutting tool in response to the detected change in the HDD machine performance characteristic.

18.   The method of claim 1, further comprising inputting a set of initial HDD machine operating parameters for controlling drill pipe or cutting tool movement, wherein executing the particular control program modifies execution of the set of initial HDD machine operating parameters.

19. The method of claim 1, wherein controlling the HDD machine comprises autonomously controlling the HDD machine to move the cutting tool along the underground path in accordance with the pre-established bore plan.

20. The method of claim 1, wherein controlling the HDD machine comprises manually controlling the HDD machine to move the cutting tool along the underground path in accordance with the pre-established bore plan, further wherein executing the particular control program augments or takes over manual control of the HDD machine.

21. A system for controlling a horizontal directional drilling (HDD) machine having a cutting tool coupled to a drill pipe, comprising:
     an above-ground locator;
     a user interface comprising a user input device; and
     a controller, communicatively coupled to the user interface, configured to control the HDD machine to move the cutting tool along an underground path in accordance with a pre-established bore plan, the controller, during HDD machine operation, accessing one or more control programs each causing the HDD machine to execute a sequence of pre-defined HDD machine actions, the controller executing a particular control program of the one or more control programs to augment movement of the drill pipe or cutting tool.

22. The system of claim 21, wherein the cutting tool comprises a boring tool.

23. The system of claim 21, wherein the cutting tool comprises a reamer.

24. The system of claim 21, wherein the user interface comprises a display.

25. The system of claim 21, wherein the user interface is situated at or on the HDD machine.

26.   The system of claim 21, wherein the user interface is situated at or on the above-ground locator.

27.   The system of claim 21, wherein a first user interface is situated at or on the above-ground locator, and a second user interface is situated at or on the HDD machine.

28.   The system of claim 21, wherein the controller is situated at or on the HDD machine.

29.   The system of claim 21, wherein the controller is situated at or on the above-ground locator.

30.   The system of claim 21, wherein the controller accesses the one or more control programs in response to a manual instruction received by the user input device.

31.   The system of claim 21, wherein the controller accesses the one or more control programs in response to a control signal generated by the controller.

32.   The system of claim 21, wherein the controller accesses the one or more control programs in response to information received from the locator.

33.   The system of claim 21, wherein the cutting tool comprises a boring tool or a reamer, and the one or more control programs define a sequence of boring tool or reamer actions to enhance progression of the boring tool or reamer through earth.

34.   The system of claim 21, wherein the one or more control programs define a sequence of rod loading or unloading actions.

35.   The system of claim 21, further comprising a mud system, wherein the one or more control programs define a sequence of mud system actions.

36.   The system of claim 21, wherein the one or more control programs comprise instructions that replicate an operator defined sequence of HDD machine actions.

37.   The system of claim 21, wherein the user input device comprises a start recording control and a stop recording control, the start recording control actuatable to initiate recording of program instructions during operator performance of the sequence of pre-defined HDD machine actions, and the stop recording control actuatable to terminate the recording of program instructions upon terminating the operator performance of the sequence of pre-defined HDD machine actions, the one or more control programs comprising the recorded program instructions.

38.   The system of claim 21, wherein the controller autonomously controls the HDD machine to move the cutting tool along the underground path in accordance with the pre-established bore plan.

39.   The system of claim 21, wherein the controller, in response to operator inputs received by the user input device, controls the HDD machine to move the cutting tool along the underground path in accordance with the pre-established bore plan, further wherein execution of the particular control program by the controller augments the operator inputs to operate the HDD machine in a semi-automatic or automatic mode.

40.   A system for controlling a horizontal directional drilling (HDD) machine having a cutting tool coupled to a drill pipe, comprising:

means for controlling the HDD machine to move the cutting tool along an underground path in accordance with a pre-established bore plan;

5   means for detecting cutting tool movement from above-ground;

means for accessing, during HDD machine operation, one or more control programs, each of the control programs causing the HDD machine to execute a sequence of pre-defined HDD machine actions; and

means for executing a particular control program of the one or more

10   control programs to augment movement of the drill pipe or cutting tool.

41.   The system of claim 40, further comprising means for confirming that the cutting tool is progressing along the underground path.

15   42.   The system of claim 40, wherein the particular control program defines a sequence of cutting tool location detection actions, and the means for detecting cutting tool movement comprises means for detecting cutting tool orientation during execution of the sequence of cutting tool location detection actions.

20   43.   The system of claim 40, wherein the particular control program defines a sequence of cutting tool location detection actions, and the means for detecting cutting tool movement comprises means for detecting cutting tool depth during execution of the sequence of cutting tool location detection actions.

25   44.   The system of claim 40, wherein the particular control program defines a sequence of cutting tool location detection actions, and the means for detecting cutting tool movement comprises means for detecting cutting tool location during execution of the sequence of cutting tool location detection actions.

45.   The system of claim 40, wherein the means for detecting cutting tool movement comprises means for detecting a deviation of the cutting tool from the underground path, and execution of the particular control program by the execution means augments movement of the cutting tool to change a heading of the cutting tool.

46.   The system of claim 40, wherein the means for detecting cutting tool movement comprises means for detecting an underground obstruction, and execution of the particular control program by the execution means augments movement of the cutting tool to avoid the detected underground obstruction.

47.   The system of claim 40, wherein the means for accessing the one or more control programs further comprises means for manually selecting the particular control program for execution.

48.   The system of claim 40, wherein the means for accessing the one or more control programs further comprises means for automatically selecting the particular control program for execution.

49.   The system of claim 40, wherein the cutting tool comprises a boring tool or a reamer, and the one or more control programs define a sequence of boring tool or reamer actions to enhance progression of the boring tool or reamer through earth.

50.   The system of claim 40, wherein the one or more control programs define a sequence of rod loading or unloading actions.

51.   The system of claim 40, further comprising a mud system, wherein the one or more control programs define a sequence of mud system actions.

52.   The system of claim 40, wherein the one or more control programs comprise instructions that replicate an operator defined sequence of HDD machine actions.

5   53.   The system of claim 40, further comprising:

means for manually performing the sequence of pre-defined HDD machine actions; and

means for storing program instructions during manual performance of the sequence of pre-defined HDD machine actions, the one or more control programs

10   comprising the stored program instructions.

54.   The system of claim 40, further comprising means for detecting a change in an HDD machine performance characteristic, wherein executing the particular control program by the execution means modifies movement of the drill pipe or cutting tool in

15   response to the detected change in the HDD machine performance characteristic.

55.   The system of claim 40, further comprising means for inputting a set of initial HDD machine operating parameters for controlling drill pipe or cutting tool movement, wherein executing the particular control program by the execution means

20   modifies execution of the set of initial HDD machine operating parameters.

56.   The system of claim 40, wherein the means for controlling the HDD machine comprises means for autonomously controlling the HDD machine to move the cutting tool along the underground path in accordance with the pre-established bore

25   plan.

57.   The system of claim 40, wherein the means for controlling the HDD machine comprises means for manually controlling the HDD machine to move the cutting tool along the underground path in accordance with the pre-established bore plan, further wherein executing the particular control program by the executing means augments or takes over manual control of the HDD machine.